



UPPER RAPPAHANNOCK RIVER BACTERIA TMDL DEVELOPMENT

Virginia Department of Environmental Quality
Rappahannock-Rapidan Regional Commission
Engineering Concepts, Inc.

FIRST PUBLIC MEETING
October 11, 2006



QUESTIONS TO ANSWER

- What is the history of the watershed?
- Who/what is producing bacteria in the watershed?
- How much bacteria is being produced by sources in watershed?
- How is the bacteria reaching the stream?
- What source reductions are needed to meet the water quality standard?



TMDL DEVELOPMENT PROCESS

● WATERSHED HISTORY

- Characterize watershed and identify critical contamination conditions

● SOURCE ASSESSMENT

- Identify and quantify pollutant sources

● MODELING

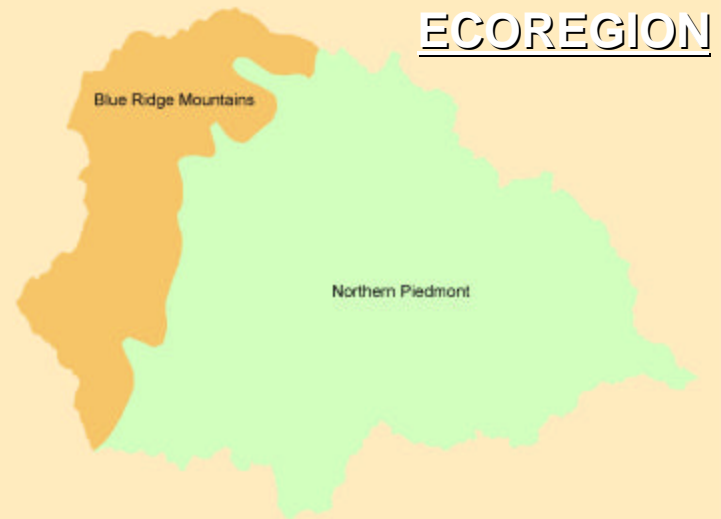
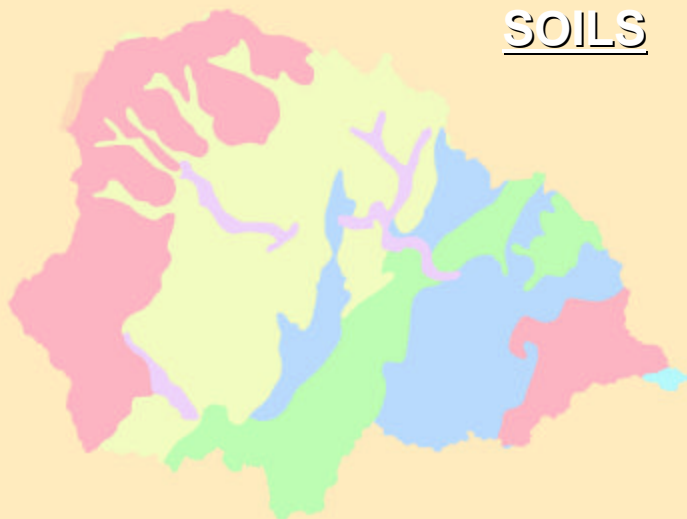
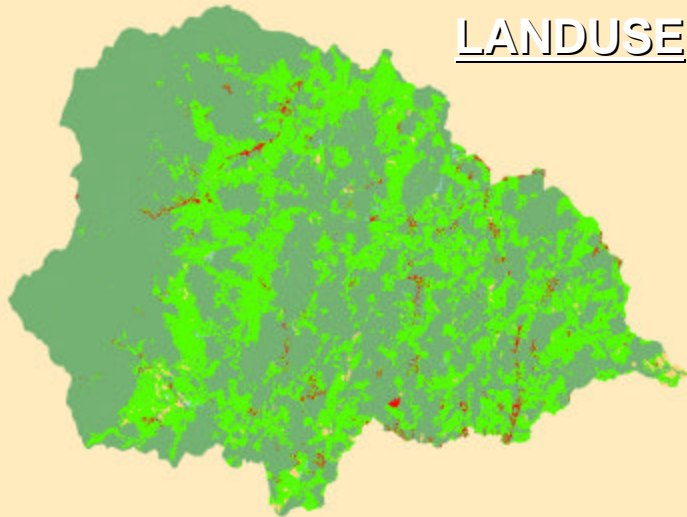
- Link pollutant sources to stream water quality

● ALLOCATION

- Develop and evaluate allocation scenarios



WATERSHED CHARACTERISTICS





WATERSHED CHARACTERISTICS

Impairment	Drainage Size (sq. mi.)	Land use			
		Agricultural (%)	Residential (%)	Forest (%)	Water (%)
Rappahannock River (VAN-E01R-03)	76	30	1	68	1
Rush River (VAN-E05R-01)	15	20	<1	79	<1
Hughes River (VAN-E03R-01)	72	25	<1	74	<1
Hazel River (VAN-E04R-01)	125	28	<1	71	<1

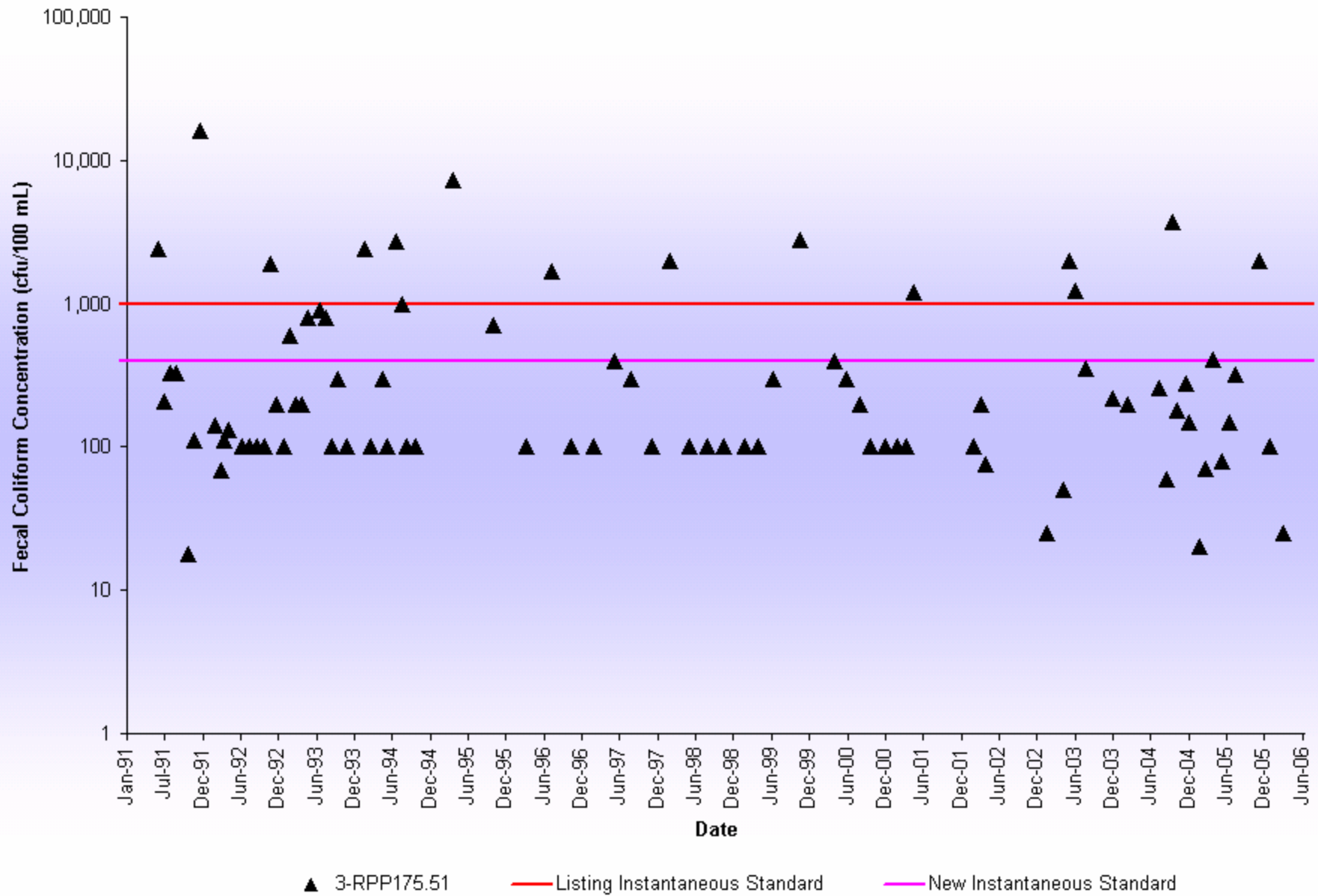


WATERSHED HISTORY

- Identify critical contamination conditions
 - Timeseries of bacteria concentration
 - Seasonality
 - Bacteria concentration versus flow

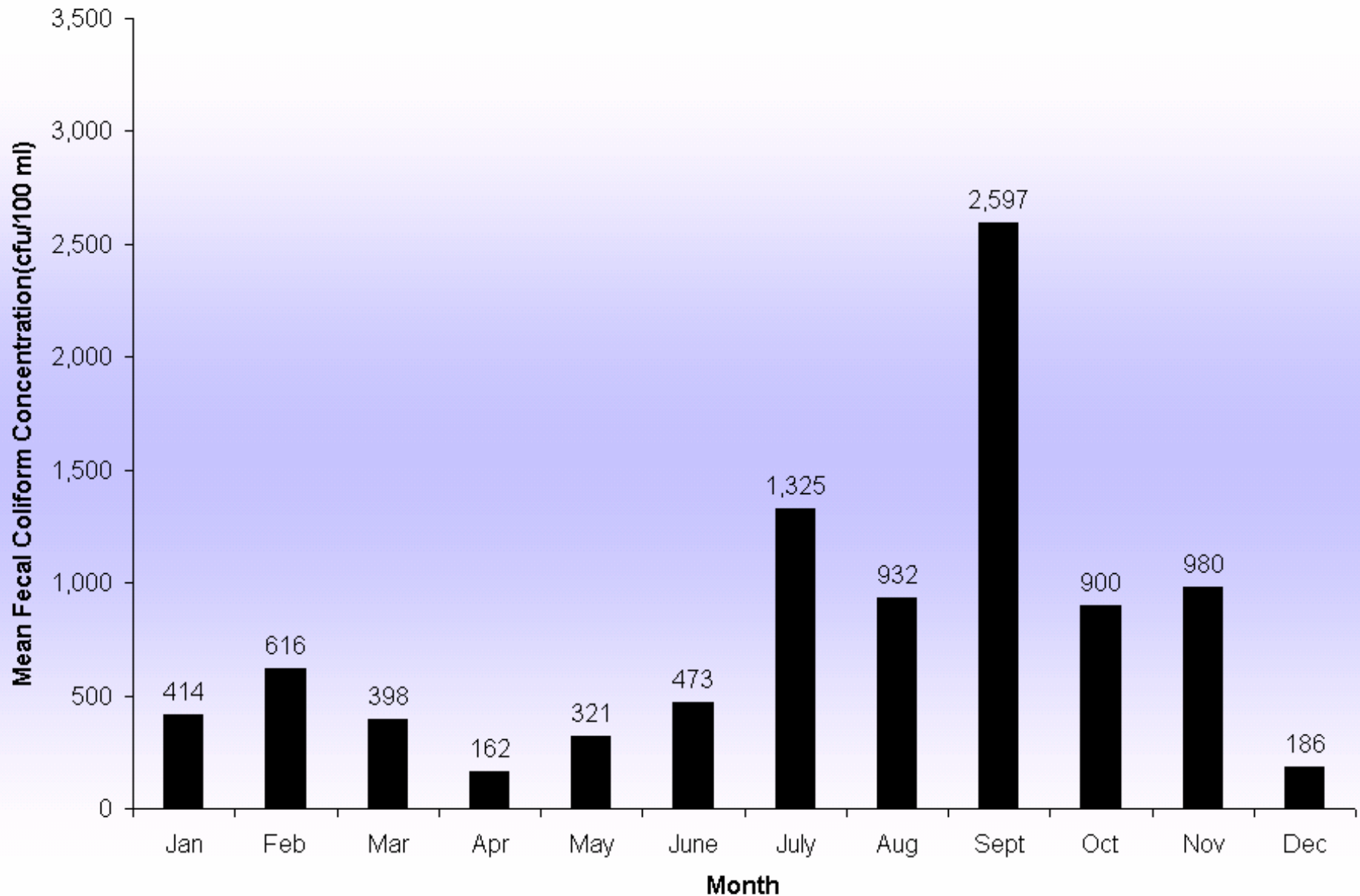


BACTERIA TIMESERIES



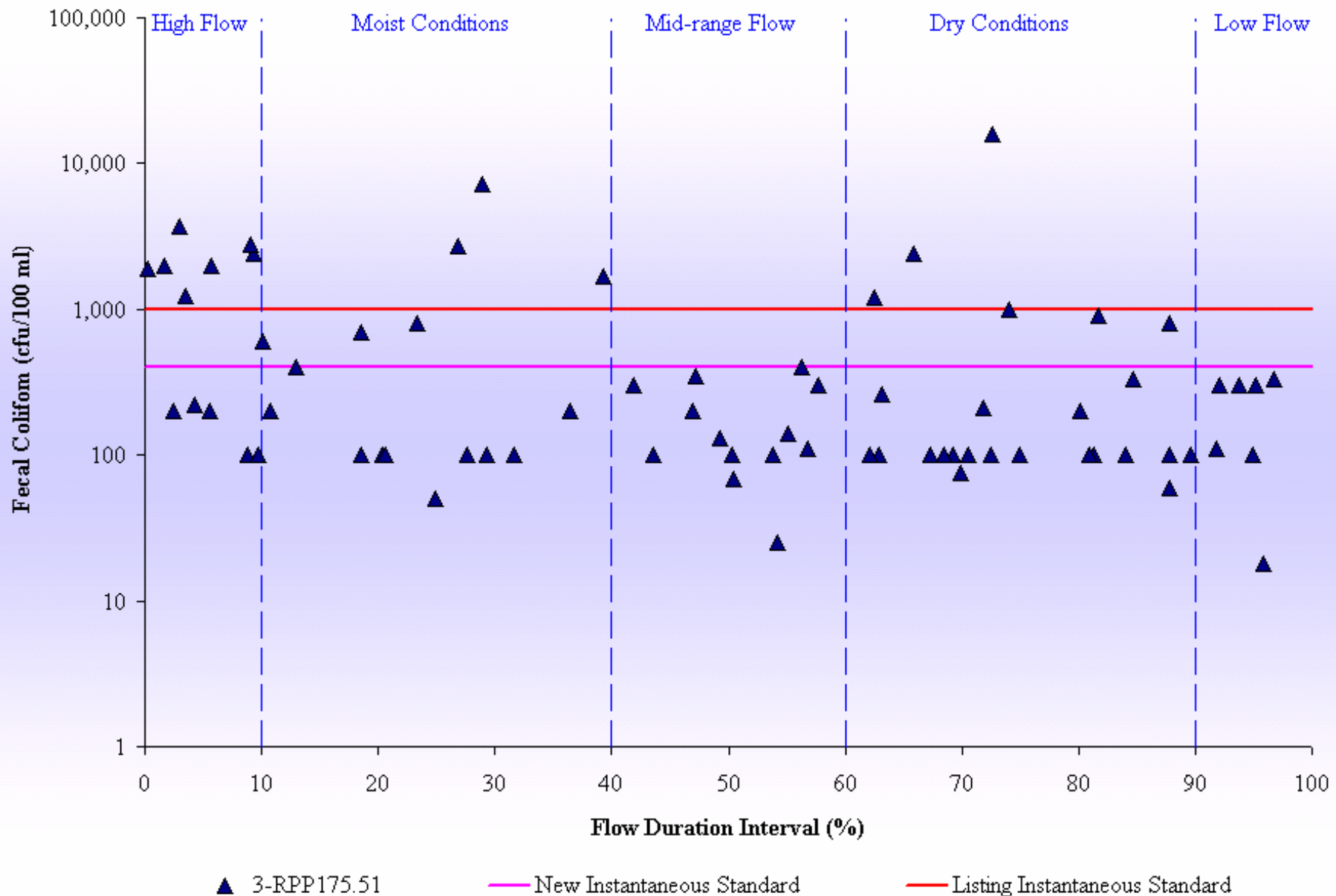


BACTERIA SEASONALITY





BACTERIA VS. FLOW



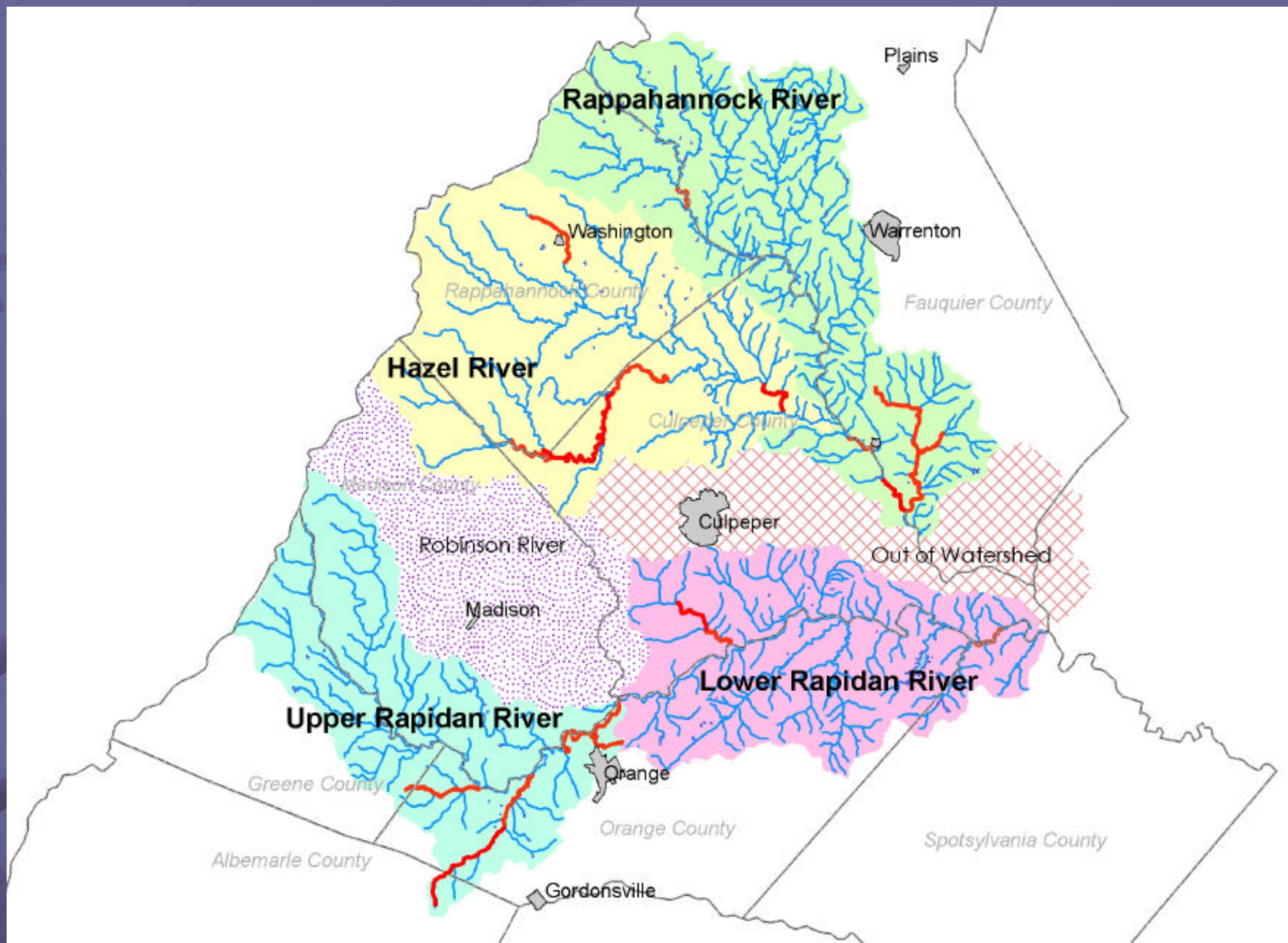


SOURCE ASSESSMENT

Source Category	Source / Animal Type
Human and Pets	Permitted Discharges
	Sanitary Sewer
	Straight Pipes
	Failing Septic Systems
	Biosolids Applications
	Dogs / Cats
Agricultural	Dairy & Beef Cattle
	Horses
	Sheep
	Chicken
	Turkey
Wildlife	Deer
	Raccoon
	Muskrats
	Beavers
	Turkeys
	Geese
	Ducks



MODEL REGIONS





RAPPAHANNOCK SUBWATERSHEDS





HAZEL RIVER SUBWATERSHEDS





PERMITTED POINT SOURCES

- Virginia Pollution Discharge Elimination System
 - Types - municipal, industrial, general
 - Categories – major, minor, general





PERMITTED DISCHARGES

Impairment	Facility Type (#)			Design Flow (MGD)	
	Municipal	Industrial	General	Minimum	Maximum
Rappahannock River (VAN-E01R-03)	0	0	0	N/A	N/A
Rush River (VAN-E05R-01)	0	1	0	0.006	0.006
Hughes River (VAN-E03R-01)	0	0	0	N/A	N/A
Hazel River (VAN-E04R-01)	1	0	0	0.015	0.015



HUMAN SOURCES

- Population, houses, onsite treatment system based on U.S. Census Bureau, municipality, & E-911 data
- Sanitary sewer
 - Loading type
 - Overflows & exfiltration
 - Land-applied / direct deposition
 - Loading type
 - Proximity to stream





HUMAN SOURCES

● Failed septic systems

- Failure to soil surface throughout year
- Failure rate based on age of home

● Straight pipes

- Direct continuous input to stream
- Based on proximity to stream and house age

● Biosolids applications

- Records kept by Virginia Department of Health
- Land-applied



Failed Septic System



Straight Pipe



PET SOURCES

- American Veterinary Medical Association estimates 0.53 dogs and 0.60 cats per household
- Potentially updated through veterinarians, animal control, treasurer, and residents
- Population = population density * houses
- Land-applied





HUMAN AND PET SOURCES

Impairment	Human Pop. (#)	Housing Unit (#)	Dogs (#)	Cats (#)
Rappahannock River (VAN-E01R-03)	2,683	1,023	542	614
Rush River (VAN-E05R-01)	377	180	95	108
Hughes River (VAN-E03R-01)	1,745	757	401	454
Hazel River (VAN-E04R-01)	5,725	2,050	1,087	1,230



LIVESTOCK SOURCES

● Population

- Virginia Agricultural Statistics
- Confined Animal Feeding Operation
- Consultation with SWCD, VADCR, VCE, NRCS, and producers
- Windshield survey



● Distribution of waste

- Confined: waste collected and spread
- Pastured: land-applied
- Stream access: direct deposition
- Imported sources



● Seasonal varying applications



LIVESTOCK SOURCES

Impairment	Beef* (#)	Dairy+ (#)	Horse (#)	Sheep (#)	Turkey (#)	Chicken (#)
Rappahannock River (VAN-E01R-03)	2,106	0	776	29	0	0
Rush River (VAN-E05R-01)	288	0	106	4	0	0
Hughes River (VAN-E03R-01)	1,632	0	599	22	0	0
Hazel River (VAN-E04R-01)	3,206	0	1,176	43	0	0

* Cow/calf pairs; + Milking herd



WILDLIFE SOURCES

- Populations based on habitat and population densities provided by Virginia Department of Game and Inland Fisheries biologists
- Distribution of waste based on habitat
 - Land-applied
 - Direct deposition to stream
- Seasonal variations based on migration patterns and food sources





WILDLIFE SOURCES

Impairment	Deer (#)	Raccoon (#)	Muskrat (#)	Beaver (#)	Geese (#)	Duck (#)	Turkey (#)
Rappahannock River (VAN-E01R-03)	1,583	1,752	3,837	198	251	126	152
Rush River (VAN-E05R-01)	448	327	695	38	51	26	36
Hughes River (VAN-E03R-01)	1,367	1,454	3,539	163	237	120	92
Hazel River (VAN-E04R-01)	2,917	2,835	6,292	318	414	209	195



MODELING

- Link pollutant sources to stream water quality
- Mathematically represent processes that are occurring in the watershed
- Processes
 - Hydrology – water balance
 - Water quality - pollutant fate and transport
- Accuracy Evaluation
 - Based on observed data
 - Flow: USGS gauge = model output
 - Bacteria: VADEQ station = model output

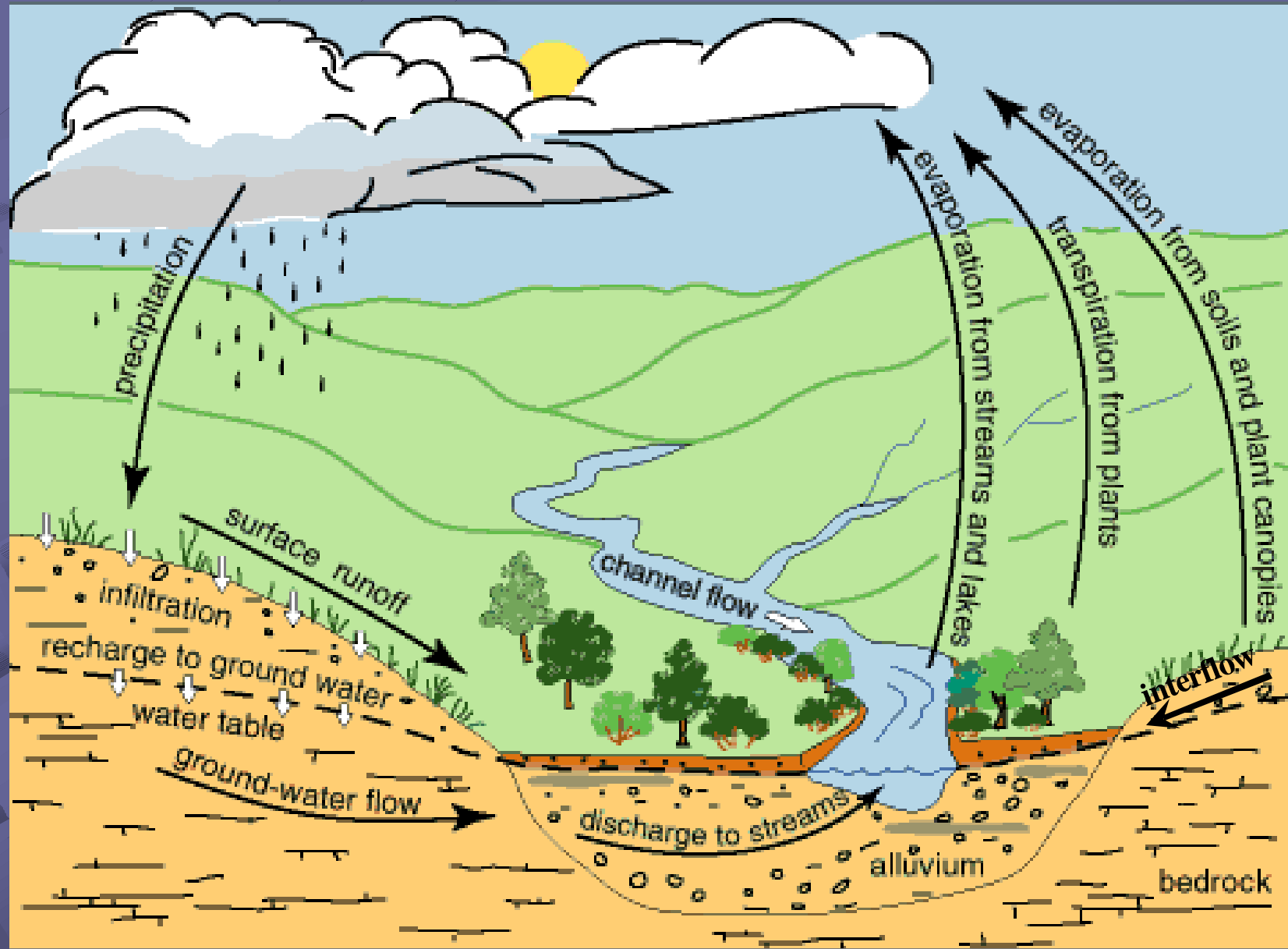


MODELING

- Hydrologic Simulation Program - Fortran
 - Developed by United States Geologic Survey
 - Seasonal patterns in climatic data
 - Simulates point and non-point sources
 - Temporal variations in pollutant loadings

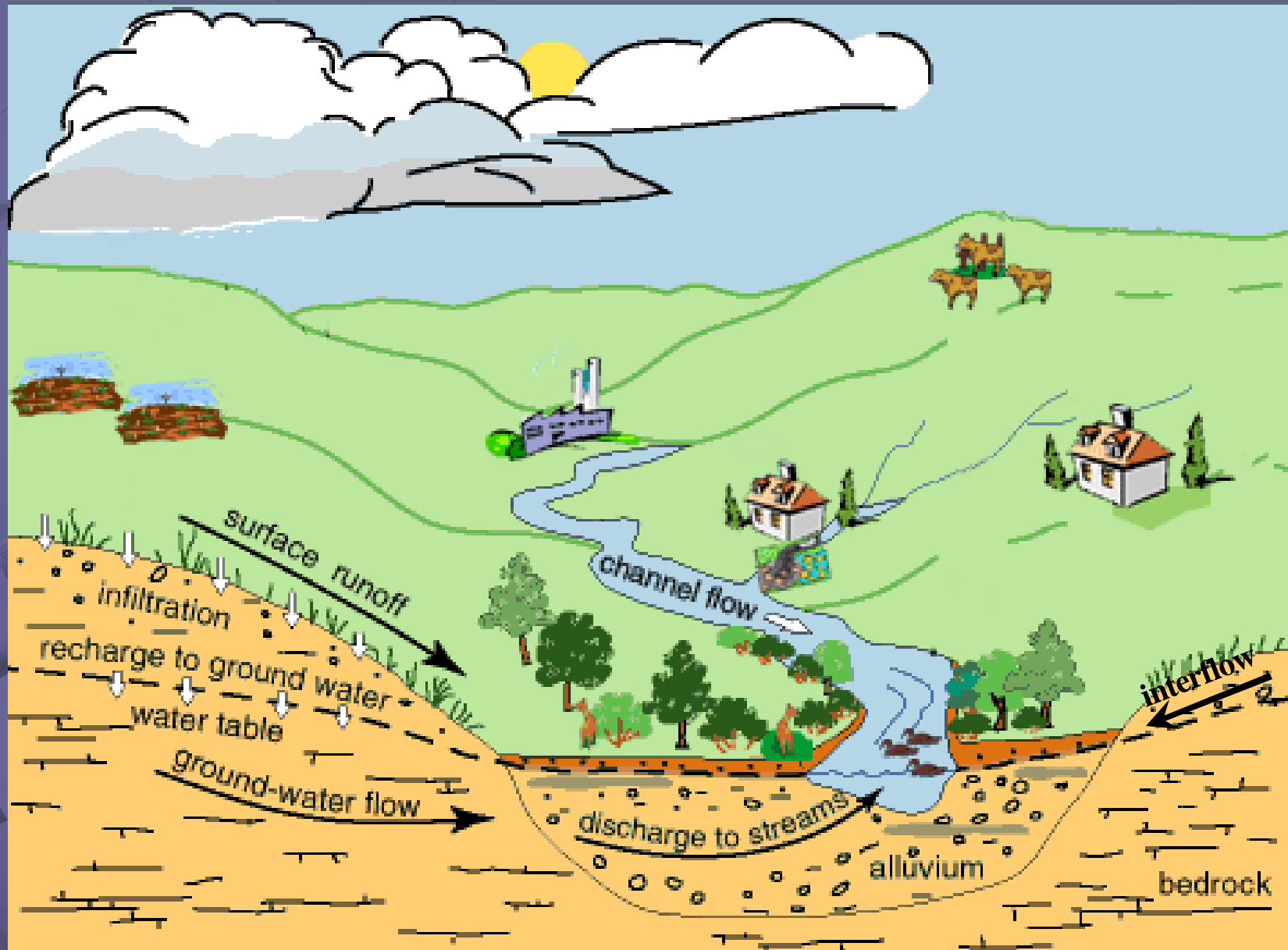


HYDROLOGIC MODELING





WATER QUALITY MODELING





HYDROLOGIC MODELING COMPONENTS

- Climatic data
- Land use
- Topography
- Soils
- Stream channel characteristics
- Point source discharge / withdrawal



WATER QUALITY MODELING COMPONENTS

● Sources

- Fecal production
- Fecal coliform densities
- Fecal coliform distribution

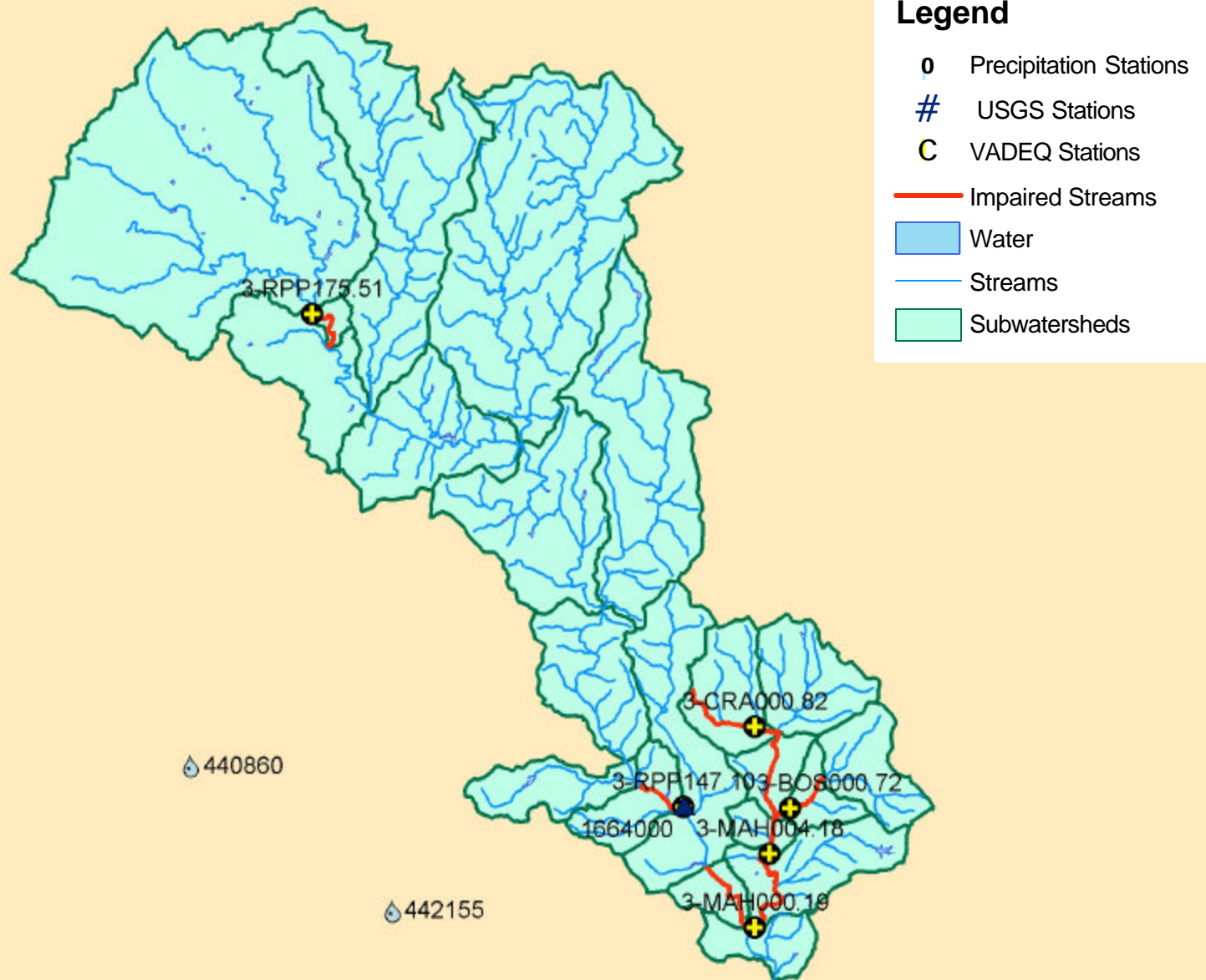
● Delivery mechanisms

- Direct
- Land-applied

● Temporal variation

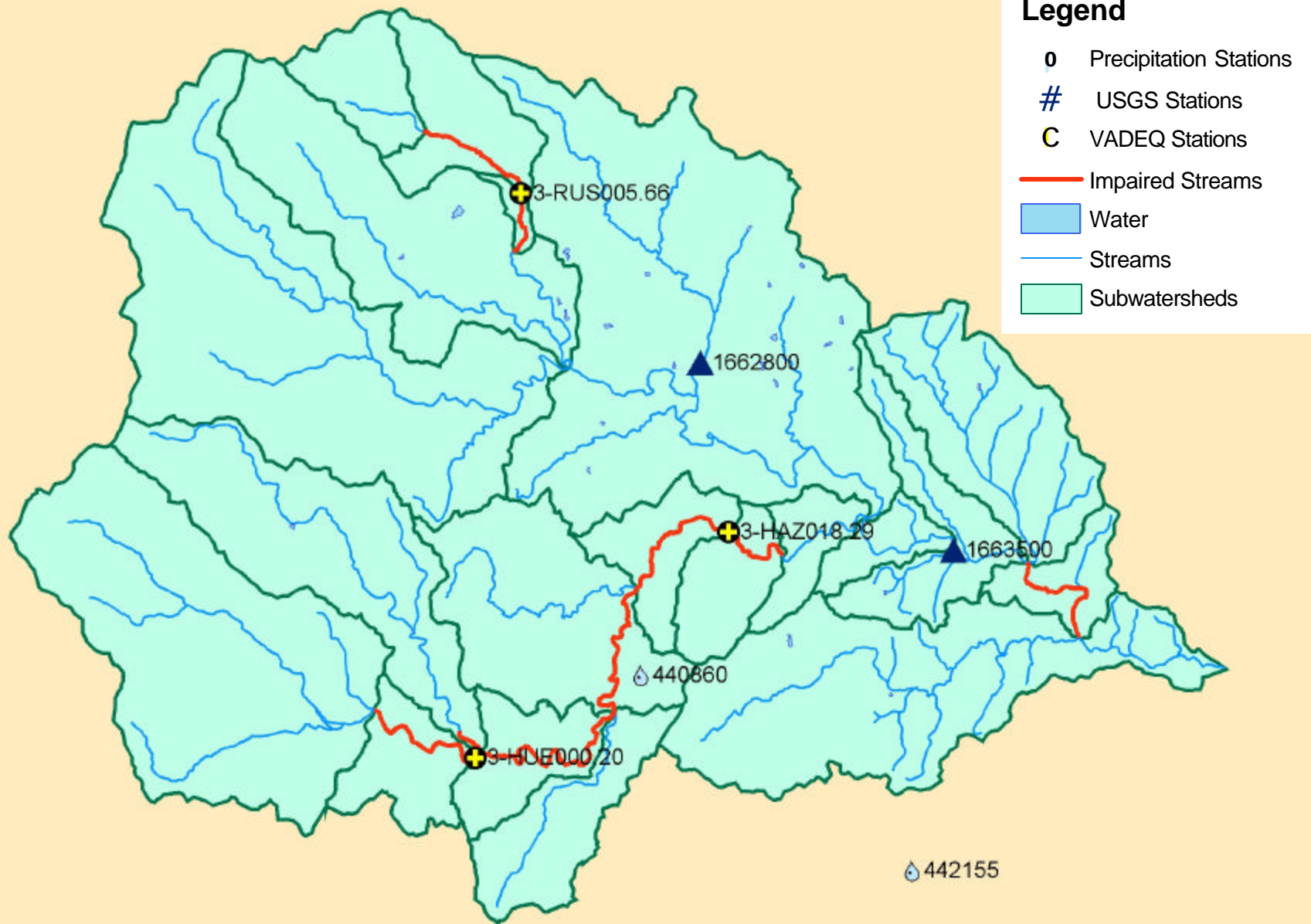


MODEL ACCURACY EVALUATION





MODEL ACCURACY EVALUATION





PRECIPITATION STATIONS

COOPID	Station Name	County	Timestep
442159	Culpeper Riverside CG	Culpeper	Hourly
446712	Piedmont Research St	Orange	Hourly
442155	Culpeper	Culpeper	Daily
440860	Boston 4 SE	Culpeper	Daily
443466	Gordonsville 3 S	Louisa	Daily
445050	Louisa	Louisa	Daily
440720	Big Meadows	Madison	Daily
445150	Madison	Madison	Daily
444692	Lake of the Woods	Orange	Daily
443462	Gordonsville FAA AP	Orange	Daily
447904	Somerset	Orange	Daily
443192	Fredricksburg Natl Pk	Spotsylvania	Daily



MONITORING STATIONS

Station ID	Waterbody	Station Type	Agency
01664000	Rappahannock River	Flow	USGS
01662800	Battle Run	Flow	USGS
01663500	Hazel River	Flow	USGS
3-RPP175.51	Rappahannock River	Bacteria	VADEQ
3-RUS005.66	Rush River	Bacteria	VADEQ
3-HUE000.20	Hughes River	Bacteria	VADEQ
3-HAZ018.29	Hazel River	Bacteria	VADEQ



ALLOCATION

1. Calculate existing loads for all sources
2. Create load reductions scenarios controlling anthropogenic sources first
3. Run model with scenarios
4. Calculate water quality standard (WQS) violation rate
5. Select scenario with 0% WQS violation rate
6. Calculate allocation loads for all sources



EXAMPLE ALLOCATION

Source	Existing Condition Load (cfu/yr)
Direct Deposition	
Straight Pipes	8.09E+13
Livestock	1.76E+12
Wildlife	5.93E+13
<i>Total</i>	<i>1.58E+14</i>
Land-based	
Residential	1.61E+14
Cropland	1.16E+13
Pasture	9.53E+15
Forest	2.95E+14
<i>Total</i>	<i>9.99E+15</i>



EXAMPLE ALLOCATION SCENARIOS

Scenario Number	Percent Reduction in Fecal Coliform Loading From Existing Conditions							% Violation of <i>E. coli</i> Standard	
	Straight Pipes	Livestock DD	Wildlife DD	Cropland	Pasture	Residential	Forest	Geometric Mean	Instantaneous
0	0	0	0	0	0	0	0	75	35
1	100	75	0	0	0	0	0	50	33
2	100	100	0	25	25	25	0	0	10
3	100	100	0	50	50	50	0	0	0



EXAMPLE ALLOCATION

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<i>Total</i>	<i>1.58E+14</i>
Land-based	
Residential	1.61E+14
Cropland	1.16E+13
Pasture	9.53E+15
Forest	2.95E+14
<i>Total</i>	<i>9.99E+15</i>

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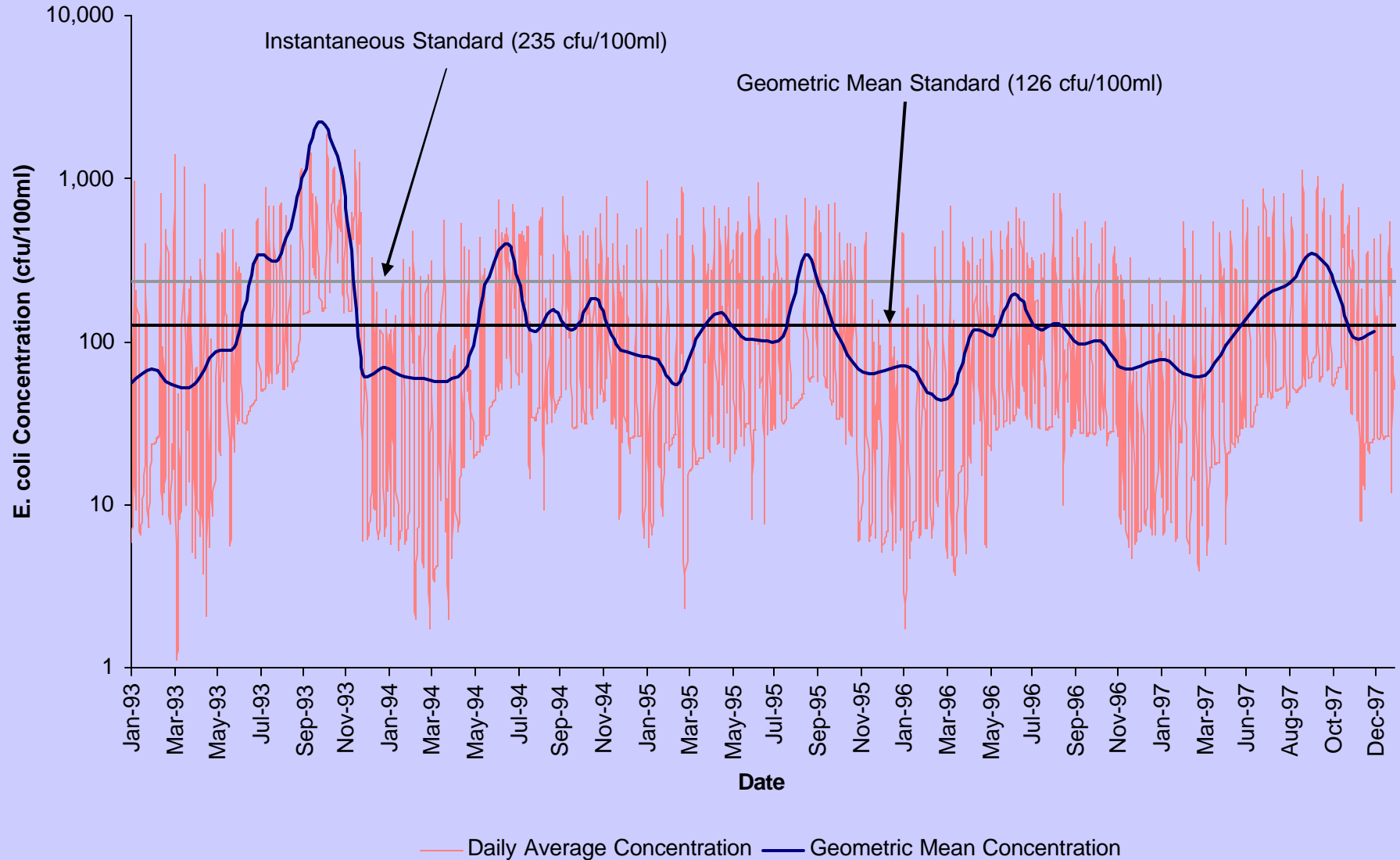
Scenario 3 Reduction (%)
100
100
0
50
50
50
0

=

Source	Allocation Condition Load (cfu/yr)
Direct Deposition	
Straight Pipes	0.00E+00
Livestock	0.00E+00
Wildlife	5.93E+13
<i>Total</i>	<i>5.93E+13</i>
Land-based	
Residential	8.05E+13
Cropland	5.80E+12
Pasture	4.77E+15
Forest	2.95E+14
<i>Total</i>	<i>5.15E+15</i>

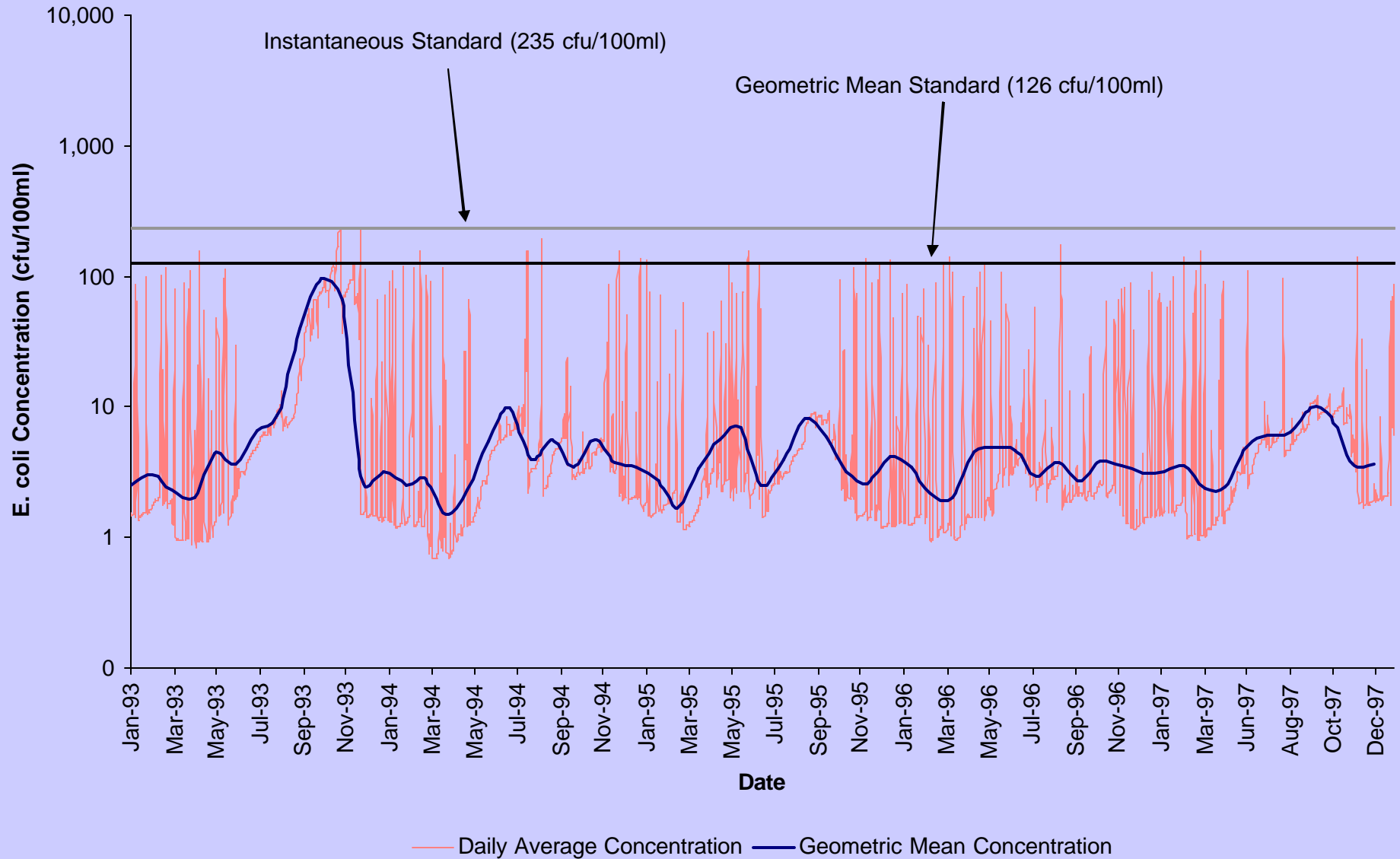


EXAMPLE EXISTING CONDITIONS





EXAMPLE ALLOCATION CONDITIONS





TIMELINE

- POLLUTANT SOURCE INVENTORY
 - Revisions based on feedback
 - Biosolids, straight pipes, failing septic systems estimates
- MODELING
 - Hydrology calibration and validation
 - Water quality calibration and validation

SECOND TAC MEETING

Presentation of modeling results and revisions to pollutant source inventory

- ALLOCATION DEVELOPMENT
 - Scenario development, assessment of scenarios, selection of allocation

THIRD TAC MEETING

Presentation of allocation scenarios

FINAL PUBLIC MEETING

Presentation of pollutant source inventory revisions, model results, allocation scenarios, and draft TMDL document



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